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THE PREPARATION OF JAPANESE LACQUER AND THE MANUFACTURE OF WAKASA LACQUER WARE.*

BY ROMYN HITCHCOCK.

Japanese lacquer is the product of a tree, the *Rhus vernicifera* D. C., which grows throughout the main island of Japan. It attains a large size, the trunks sometimes measuring a meter in diameter. It is said the tree will live for forty years, but only comparatively young trees are valued for the production of lacquer. Having yielded for several years they are cut down, the lacquer extracted from the branches, and young trees take their places.

The principal section of the lacquer industry is between the parallels of 37° and 39°, beginning about one hundred miles north of Tokio. The best lacquer, however, comes from much farther south, from Yoshino, in Yamato.

The lacquer exudes from horizontal cuts in the bark, in the form of a rather viscid emulsion, and may be collected from April to the end of October. In the spring it is more watery than in the later months. However, the sap never flows so freely that it can be collected in vessels, as has been stated by writers. It exudes slowly and is collected by means of a pointed spoon-like instrument and transferred to a wooden receptacle or tube of bamboo. Several cuts (6–10) are made in each tree, the last as high as a man can reach. Having thus prepared a dozen or more trees in rapid succession, the collector begins to collect the juice from the cuts in regular order, beginning with the one first cut.

Having finished the collecting he takes other groups of trees, and after about four days returns to the first, where, after removing the accumulated yield, he cuts again into the same trees, and repeats the same role fifteen or twenty times. Thus the work may go on for eighty to a hundred days. The utmost yield of a single tree is about 40–50 c. c. of raw lacquer.

As the sap first exudes it is a grayish-white thick or viscous fluid, which quickly turns yellow, and afterwards black where it is in contact with the air.

The sap thus collected is *ki-urushi*, *urushi* being the general name for lacquer. An inferior kind is obtained from the branches when the trees are cut down. The branches are soaked in water for several months, then taken up and slightly warmed, when a small quantity of sap exudes. This is *seshime urushi*.

The lacquer is strained through cotton cloth to free it from bits of wood and dirt, first being thoroughly stirred to break up lumps and make a uniform mixture.

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The product thus purified is known as *seshime urushi*, but this name, which has already been used to designate the lacquer from the branches, has now a different meaning and is applied to the cheaper kinds of raw lacquer, such as are used for the first coats in lacquering. These lacquers have usually lost some of their water by stirring in shallow receptacles exposed to the sun. They have undergone no further preparation.

Many varieties of lacquer are prepared for special purposes, ranging in price from $1 or $2 to $6 or $7 per kilogram. These differ in quality and color. There is a famous black lacquer prepared by the addition of iron which forms a chemical combination to be mentioned further on; while red, green, yellow, and other colors are imparted by addition of various pigments, as cinnabar for red, orpiment and indigo together for green, orpiment for yellow, etc. Ultramarine is decomposed by lacquer, giving off sulphuretted hydrogen. Certain lacquers have a small proportion of a drying oil, *ye no abura*, perilla oil, added to them. The lacquer known as *shiu urushi*, the use of which will be referred to soon, contains from 1 to 10 per cent. of this oil. The name *shiu urushi* means cinnabar lacquer, and is applied to this variety because it is commonly used to mix with cinnabar when a red lacquer is required.

The chemical composition of lacquer has been well studied by Dr. J. J. Rein,* and later by Korschelt and Yoshida.† From the writings of these authors I have gathered most of the information here presented relative to the chemistry of the subject.

The emulsion as it comes from the tree consists of an aqueous fluid holding in suspension numerous very minute brown globules and a smaller proportion of lighter colored larger globules. The former are insoluble in water but soluble in alcohol. The latter dissolve in water.

The raw lacquer is almost completely soluble in alcohol, ether, carbon bisulphide, benzine, and solvents of gum-resins in general. The most important and abundant constituent is urushic acid, which occurs in the form of the minute spherules already mentioned. The acid is obtained by evaporating the alcoholic solution to a sirupy liquid. The evaporation must be carried on over a water-bath. If too much heat be applied a tough, black, rubber-like substance is obtained, which I found very troublesome to remove from the dish, and only strong nitric acid would affect it in the slightest degree.

As thus obtained, urushic acid yields on analysis numbers corresponding approximately with the formula $C_{14}H_{18}O_2$. This is the formula assigned to the acid by Korschelt and Yoshida. It is soluble in alcohol, chloroform, etc., but quite insoluble in water. It possesses marked acid properties, turns litmus paper red and forms salts with metals. With iron salts it forms a black compound, to which the color of the fine roiro

* Oesterreische Monatschrift für den Orient 1882, and Japan nach Reisen und Studien, vol. ii.

† Trans. Asiatic Soc. of Japan, xii (1884) 182–229. Also Forestry and Forest Products. Edinburgh, 1885.

lacquer is due. With plumbic acetate it yields a gray, flocculent precipitate.

Although the drying, or rather the hardening, properties of lacquer are doubtless due to the oxidation of urushic acid, the product extracted by alcohol, as described above, possesses no drying qualities. This fact was first observed by Professor Rein, in 1874. More recently Korschelt and Yoshida have investigated the process of lacquer hardening, and have found that a peculiar albuminoid of lacquer effects the drying by a diastatic or fermentive action. It is rather surprising that some one has not ascribed the result to a new species of bacterium, but this is doubtless due to the fact that the microscopists and bacteriologists have not yet got to work on lacquer. The fact seems to be that the lacquer hardens only when the albuminous substance is present. If heated above 60° C., or above the temperature at which albumen coagulates, the lacquer will not dry.

The authors mentioned regard the drying as a process of oxidation brought about in some way by the albuminoid, $C_{14}\ H_{18}\ O_2+O=C_{14}\ H_{18}\ O_3$. Professor Rein, however, maintains that the process of hardening is not so simple, for the reason that moisture is essential to the drying of lacquer. The drying takes place only within a narrow range of temperature—between 20° and 27° is the most favorable; Korschelt and Yoshida have shown that no water is taken up by the acid in drying.

The strongest evidence of the importance of the albuminoid to the hardening process is found in the fact that while the urushic acid will not dry by itself, it immediately hardens if a portion of the unboiled gum and albumen that does not dissolve in alcohol be added to it, and the rapidity of hardening depends upon the proportion added. It is notable that the albuminoid does not lose its peculiar property of effecting this oxidation by treatment with alcohol. This nitrogenous constituent obtained from the aqueous solution has not been satisfactorily studied. It seems to contain less hydrogen than albumen.

Besides urushic acid and the albuminoid raw lacquer contains a gum resembling gum Arabic, which doubtless imparts some useful properties to the lacquer, and a volatile acid, to which Professor Rein ascribes the poisonous effects of lacquer.

The proportion of urushic acid varies from 85 to 60 per cent. in different samples; of gum, from 3 to 6 per cent.; nitrogenous substance, 2 to 3 per cent.; water, 9 to 33 per cent.

Oxyurushic acid, the product of the oxidation of urushic acid, as already explained, may be obtained by treating urushic acid with chromic acid. The mixture becomes first pasty, then solid, and of a brown color. The product was analyzed and gave the formula $C_{14}\ H_{18}\ O_3$. It is insouble in every solvent tried: caustic alkalies, hot or cold, boiling hydrochloric and sulphuric acids have no effect. Boiling nitric acid converts it into a yellow mass, which gradually dissolves.

The investigations of Korschelt and Yoshida included the study of

several salts of urushic acid and the preparation of several of its derivatives, as hexabromurushic acid and dinitrourushic acid, and some excellent suggestions for improving the quality of lacquered articles.

We now come to the further preparation of lacquer for use in the manufacture of the several varieties of lacquered articles, and I would say that whoever is sufficiently interested in the subject to spend an hour at the National Museum will find the process of manufacture very fully illustrated there.

A portion of the raw lacquer, about 16 pounds, is poured into a large circular wooden vessel, and vigorously stirred with a long-handled tool for five or six hours, while the heat of a small charcoal furnace is ingeniously thrown upon the surface to evaporate the water. During the stirring certain ingredients may be added from time to time. I have seen this operation as conducted in Osaka. The *roiro*, a fine black lacquer, is made by adding iron at this stage. In Tokio a soluble salt of iron is used, but the Osaka manufacturer objects to that, asserting that it injures the quality of the lacquer. The material used in Osaka was the fine iron dust collected from the grinding of knives. This was added in quantities of about a tea-cup full of powder mixed with water at a time, until the desired color was obtained. When the work is finished the lacquer is poured into a vessel to settle and is afterwards drawn off from the sediment. The various other additions made to the raw lacquer in the course of manufacture have already been mentioned.

The wood generally used for lacquer work is the light, easily-worked *hinoki*, a coniferous wood from the *Chamæcyparis* (*Retinospora*) *obtusa*. It is prepared to receive the lacquer in various ways. For inferior work it is first covered with paper, but in the finer qualities paper is not used. The operations to be described apply to the manufacture of that variety of lacquer known as Wakasa lacquer, and are from personal observation. The wood is first carefully smoothed and the corners of the boxes strengthened by gluing pieces of cotton or hemp cloth around them with raw lacquer. All joints and imperfections are then filled with *tsugi urushi* (*tsugi*, to fasten), which fills like putty. This is a dark-colored mixture composed of rice flour made into a paste with water and mixed with *seshime urushi*. It soon hardens so that it can scarcely be cut with a knife. Sometimes finely cut hemp is mixed with the *tsugi urushi*. The tool used for this work is the *take no hera*. The work is then covered with *jinoko*, a mixture of *seshime urushi* and a coarse powder of a yellowish color. The mixture is soft, of a yellowish-brown color, changing to black by exposure to the air. It is spread with a wooden instrument called *hera*. You will observe that the specimen box is only covered on the bottom and the outside with this mixture. This is because it is only deemed necessary to cover those parts most subject to wear. The article is left for a few days in the open air to allow some of the water to evaporate, after which it is placed in a moist-

air closet to harden. In this way a very hard, gritty surface is obtained, affording an excellent ground for the succeeding coat.

This process is not applied in making inferior goods. For these a mixture of the powder with glue is sometimes used, and for this reason cheap ware sometimes blisters when used with hot water, the glue swelling if the water reaches it. Similar blistering may also be occasioned by the natural gum of the lacquer if it should be present in excessive quantity.

The next process consists in covering the entire box with two coats of lacquer, containing a finer powder known as *tonoko*, which is a kind of ochre much used in Japan for cleaning and polishing. This is likewise evenly spread with the *hera*. Three coats of this are applied over the joints. The object of this process is to secure an even, smooth-grained surface for subsequent work. The surface is finally rubbed down with a kind of stone called *toishi*.

The parts that are not to receive any decoration are now ready for the finishing applications of lacquer. The other parts are next covered with a black lacquer, *naka muri urushi*, which you will see is in this instance applied to the outer surfaces and top edges of the sides. The lacquer used is *shitaji urushi* mixed with a kind of black lacquer known as *honkuro*, *hon* meaning not false, *kuro*, black. This is probably the best kind of roiro lacquer. It is applied with a brush, and requires to be rubbed down. The specimen has not been rubbed.

Two coats of black lacquer are now applied. The first is *roiro* put on with a broad brush. This dries with a brilliant reflecting surface. When quite hard the second application is made, and in this, while still soft, the designs are impressed. I use the word impressed because in the Wakasa lacquer there is no painting or drawing, but the figures are produced in a very curious manner. The white decoration is applied by dropping egg-shell powder in patches here and there. This is done very skillfully by the hand. The other designs are made by pressing various forms of leaves into the soft surface. Thus, the radiating or wheel-like pattern is produced by so arranging the needle-like leaves of the pine, the more complex leaf-pattern with the leaves of an evergreen (*Thuya orientalis*), while many other effects are made by scattering over the surface husks of rice, and these mingled with very short pine needles. The mother of pearl from shells is also used. You will understand this perfectly by inspection of the specimen which shows this stage of the work. The designs become more or less modified by the subsequent operations.

The lacquer retains the impressions thus produced, when, after the leaves, etc., have been imbedded about a day, everything except the egg-shell powder and mother of pearl is removed. The article is then put in the moist closet until it is thoroughly hardened, which may require ten days or a fortnight. The egg-shell is in little heaps, the leaf impressions are beneath the general surface. It is now necessary to fill

up all depressions and once more secure an even surface. The first step is to rub down the most conspicuous projections until there is much less irregularity of surface, but even after several successive coats of lacquer there will remain some elevations and depressions.

The next application is a transparent lacquer colored yellow with arsenic sulphide. This is put on with a *hake* and spread as evenly as possible. The object of this is to afford a yellow ground for the gold which is to follow.

A thin coat of *shiu-ai urushi* is spread over this and the whole completely covered with gold leaf. Then successive coats of the same lacquer, which is a transparent red lacquer, are applied until the surface is quite even. The surface then appears entirely black, beneath which all the gold and decorations are concealed.

Instead of a red ground, green is sometimes desired, as in *awo urushi* or green lacquer. To make this the *shiu urushi* is mixed with a green pigment. Two samples of the green variety of Wakasa lacquer are shown on the sample board. The green lacquer is known as *seishitsu.*

The next operation is to rub down the surface with stone *toishi* or *sai kido* until the design is again visible. The pattern is now revealed in gold with the pure white of the egg-shell powder to relieve the effect.

The work is finally rubbed with a special kind of charcoal, known as *hozumi*, which is made from the wood called *hinoki.* This gives a perfect surface, but to make it more brilliant it is covered with a finishing coat of fine lacquer *tsuya urushi.*

I have chosen the Wakasa variety of lacquer for description because I have had better opportunities to observe the different processes in this branch of lacquer work than in the others. Moreover, it has not been hitherto described in detail, so far as I am aware, and, indeed, it is a kind of lacquer far less common in the home as well as in the foreign market. Because of the good quality of the materials used and the quantity of gold required, it is more expensive than the common varieties and more durable. Descriptions of the methods of painting and decorating other kinds of lacquer ware may be found in various publications.

To make practical application of these remarks I would say that the peculiar qualities of lacquer make it seem worthy of more consideration than it has received in this country. It gives a surface to wood much harder than our best copal varnish, without brittleness. It takes a polish not to be excelled which lasts for centuries, as we may see in the old treasures of Japan. It is proof against boiling water, alcohol, and, indeed, it seems to be insoluble in every agent known. It is the best possible application for laboratory tables. I have a set of photographer's developing trays, one of which is before you, that has been in use for more than a year, and I find them excellent and cheap. In Japan it is used for many household articles, some of which are before you.

A very serious objection to the use of lacquer in this country is the danger of lacquer poisoning from the fresh material. I have recently heard of a piano-maker who tried to use it, but it affected his workmen so seriously that he was obliged to give it up. The Japanese are very much in dread of the poison, as I found when I tried to get some of my students to accompany me as interpreters to the places of manufacture. Those who are subject to the poison suffer precisely as patients afflicted by the *Rhus* or poison-ivy. Of course those engaged in lacquer work are not affected by it, but whether one acquires immunity after a time I am unable to tell. However, if the poison is a volatile acid, as Rein supposes, it would seem possible to remove it by a heat that would leave the lacquer uninjured, and thus make it available for use in this country.

A FOSSIL LINGULA PRESERVING THE CAST OF THE PEDUNCLE.*

BY CHARLES D. WALCOTT.

The known examples of the preservation of the cast of any of the fleshy parts of a brachiopod in a fossil state are very few. Two only have heretofore come under my notice. One is the peduncle of *Eichwaldia subtrigonalis*, figured by Davidson from a silicified specimen collected from the Black River limestone in Canada (Mong. Brit. Foss., Brach., Vol. III, p. 192), and the other the peduncle of *Lingula? lesueuri*, figured by the same author (Vol. IV, p. 362, pl. xl, fig. 16).

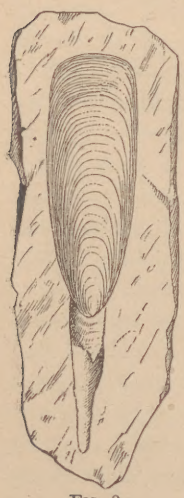

FIG. 2.

FIG. 1.

FIG. 3.

Figures 1 and 2 are copies of the original figures.

FIG. 1.—*Eichwaldia subtrigonalis*, showing peduncle issuing from the beak of the ventral valve (after Davidson).

FIG. 2.—*Lingula? lesueuri*, showing peduncle issuing from between the valves (after Davidson).

FIG. 3.—*Lingula æqualis* Hall, showing peduncle extending out from the ventral? valve.

The specimen to which I now call your attention shows the interior of the anterior portion of the ventral valve of the *Lingula æqualis* Hall, collected near Rome, N. Y., from the upper portion of the Lorraine Terrain. The portions of the shell remaining in the matrix show the median ridge extending back from the divaricator muscular scar, the reflex portion of the shell forming the false area and the groove for the passage of the peduncle. The portion of the peduncle preserved is nearly as long as the entire length of the shell.

I am indebted to Mr. William P. Rust, of Trenton Falls, N. Y., for the use of the specimen illustrated. It will be deposited in the collection of the U. S. National Museum.

* Read before the Biological Society of Washington, December 3, 1887.